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Development of macroscopic evacuation model for BIM-FSE integration

Vladimir Grachev

Natomas Engineering, Sacramento, USA
SITIS Ltd, Ekaterinburg, Russia

Email: vgrachev@natomaseng.com

Combining BIM and FSE evacuation models

“Golden thread of information” – BIM and FSE modelling integration in design workflow.

BuildingSmart project «Fire Safety Engineering & Occupant Movement openBIM Standards» – at meetings and webinar were test cases discussed – in was mentioned a problem that there is a lot of data to be processed and stored in the BIM model for agent based evacuation analysis.

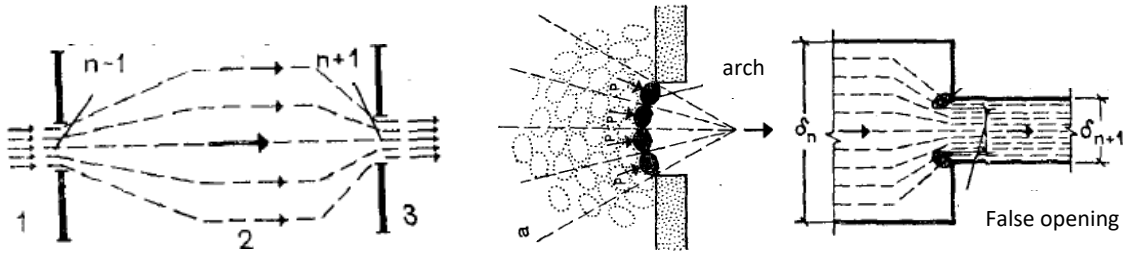
The idea of the development of macroscopic evacuation model for BIM-FSE integration is

- the ability to be easily converted from BIM model in BIM authoring software
- Relatively small amount of evacuation calculations data to be stored back in BIM model for visualization and reporting

Macroscopic evacuation model - pedestrian flows

Computational model is based on the principles and data from the monographs and research papers

- V M Predtechenskii «Planning for foot traffic flow in buildings» - main pedestrian flow properties
- SFPE Handbook - flow boundary layers
- V A Kopilov «Study of the parameters of people's movement during forced evacuation» - flows with high density
- D A Samoshin «Composition of human flow and parameters of their movement during evacuation» - flows of different type of pedestrian (elderly, children, sick, etc)



Flow properties in the model

- Flow speed is the function from the density, type of compartment (corridor, door, stair, etc), width and slope
- Flow properties – maximum width in wide spaces, angle of extension, angle of narrowing
- Flow speed function at areas of flow concentration ("doors") must take into account «arch effect», «false opening» effect and similar effects of «turbulent» pedestrian flow
- Flows can have boundary layers. Boundary layer width depends of compartment boundary type (wall, railing) and it height

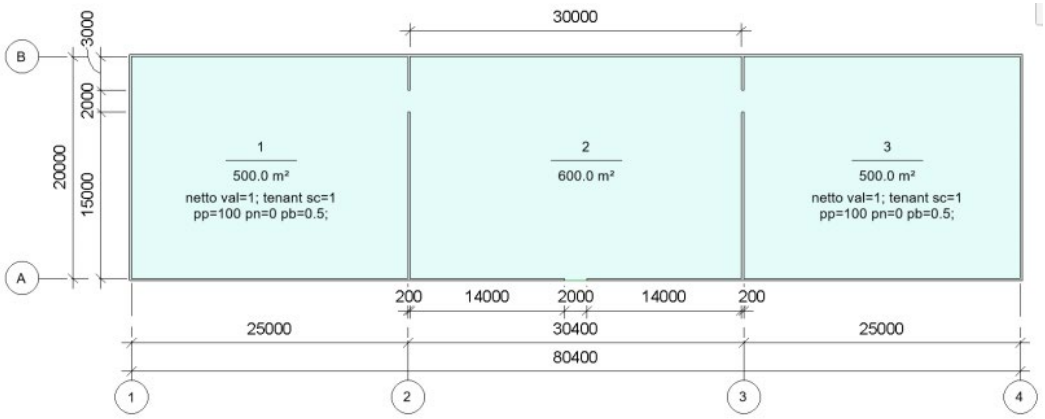
Space and time discretization

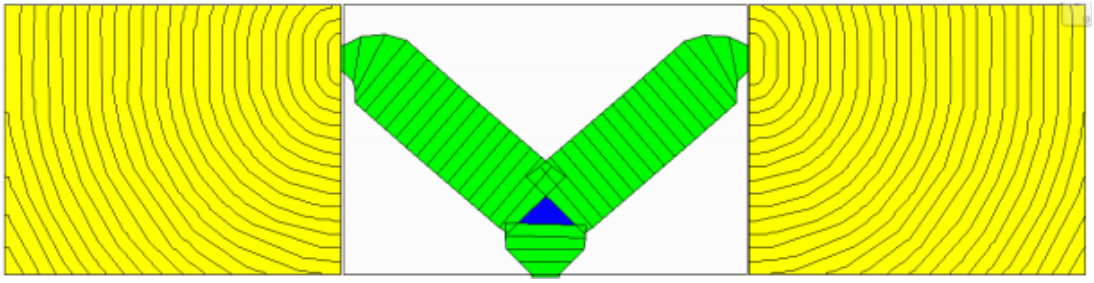
Parameter of time discretization - calculations time step

Parameter of space discretization - length of flow path field

Three types of flow path fields

- Flow formation – freely moving pedestrians (yellow)
- Direct flow (green)
- Flow merging (blue)





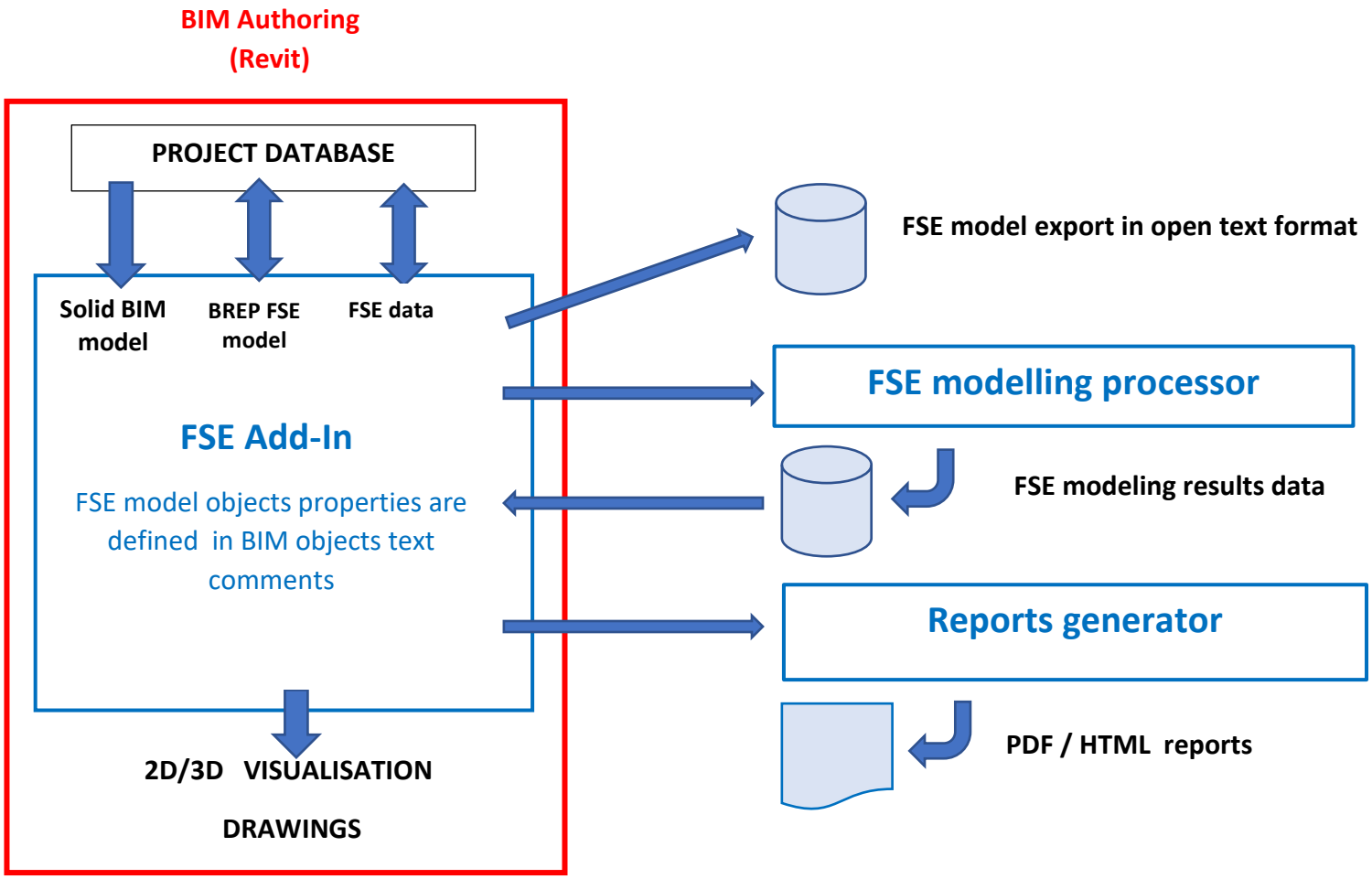
Evacuation scenarios

Evacuation scenario – a combination of FSE model options:

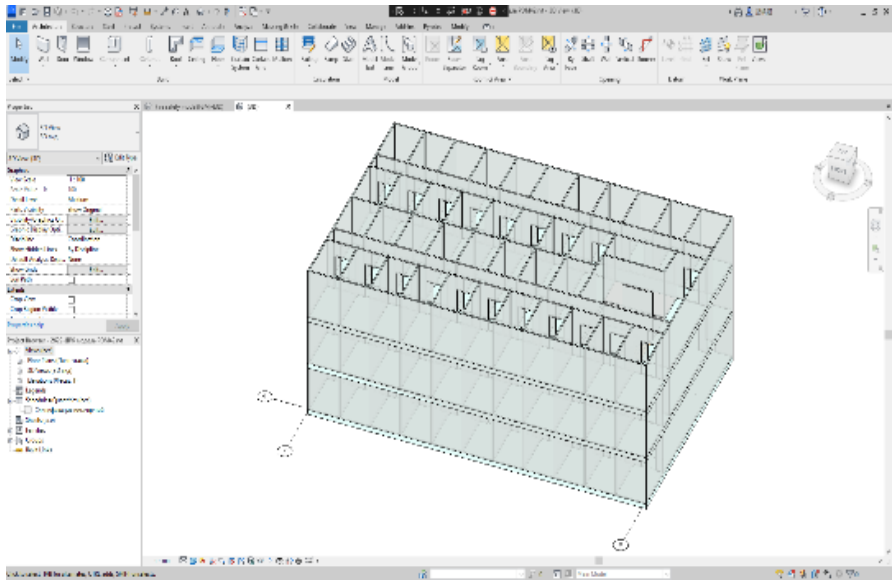
- Tenant distribution – tenant groups types, initial density in compartments, evacuation start time
- Available exits
- Doors state – open or closed
- Obstructions – existence and locations
- Set of functions speed / density

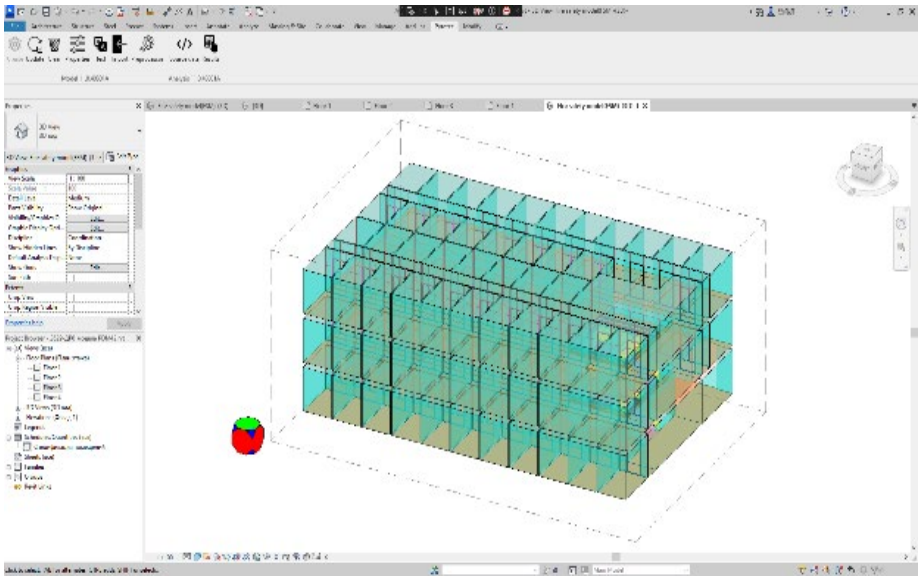
Scenarios in form of option combinations make it easier to produce event trees for fire risk assessment

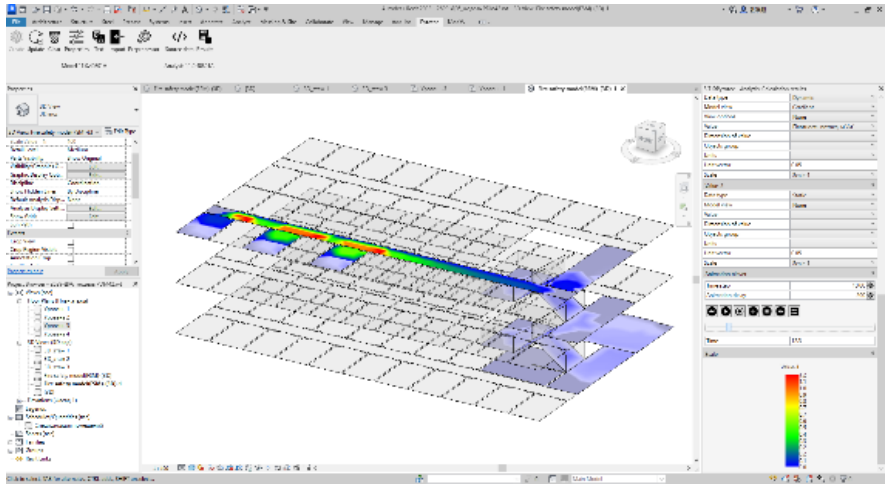
Software applications kit

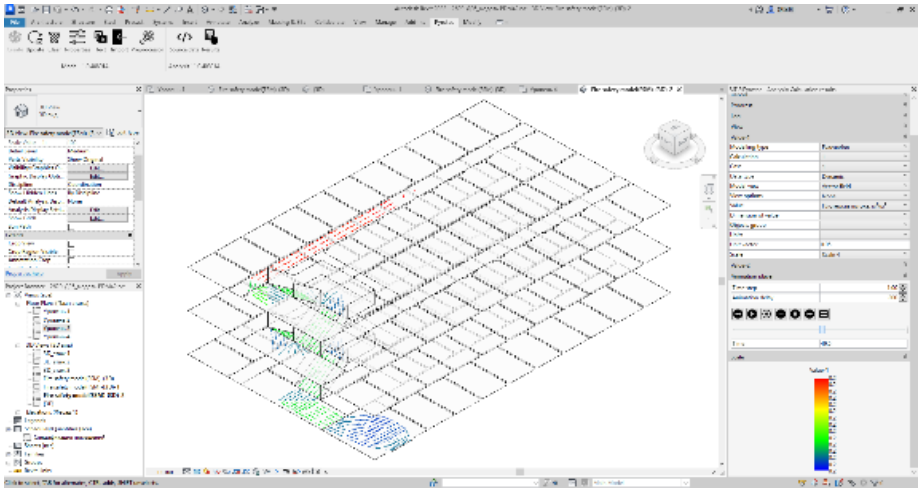


BIM and FSE models and data spatial fields visualization



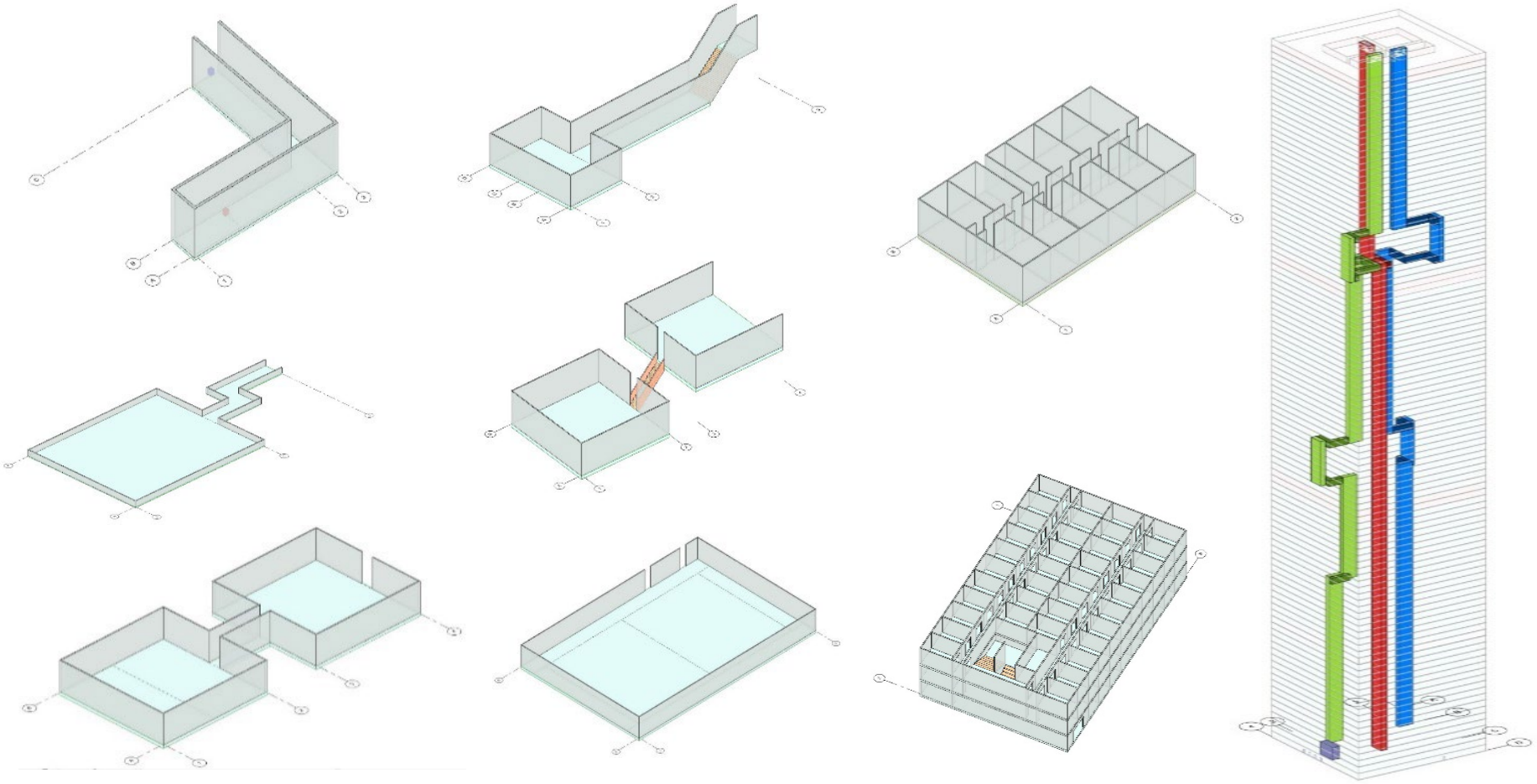






Model verification - test cases models

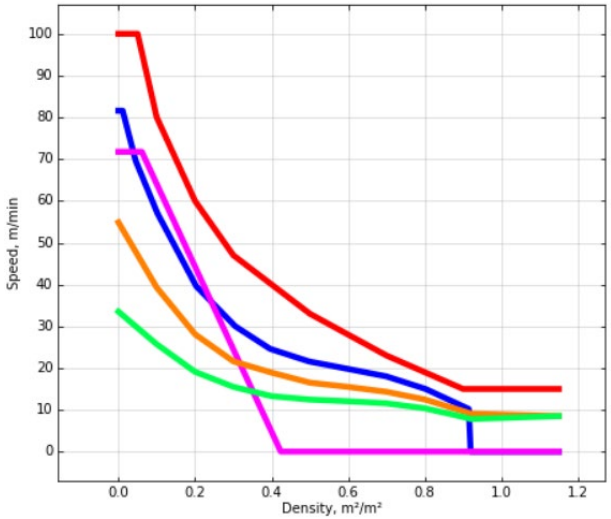
About 30+ Revit BIM models - IMO 1-4, RIMEA, ISO 20414, FDS-EVAC, NCSTAR 1-7



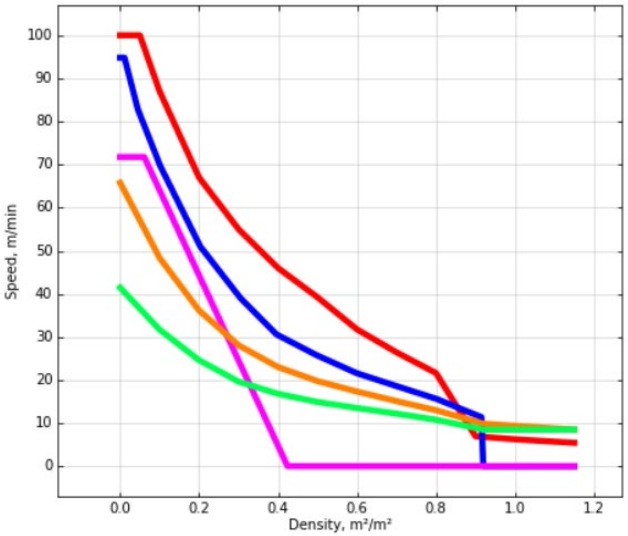
Model verification - fundamental diagrams options

- Fire risk assessment guidance, order No 749, Russia
- DIN 18009-2, Germany – Predtechenskii, extremal movement
- SFPE Guide, USA
- Predtechenskii, normal movement at density < 0.92, extremal movement at density > 0.92
- Predtechenskii, comfort movement at density < 0.92, extremal movement at density > 0.92

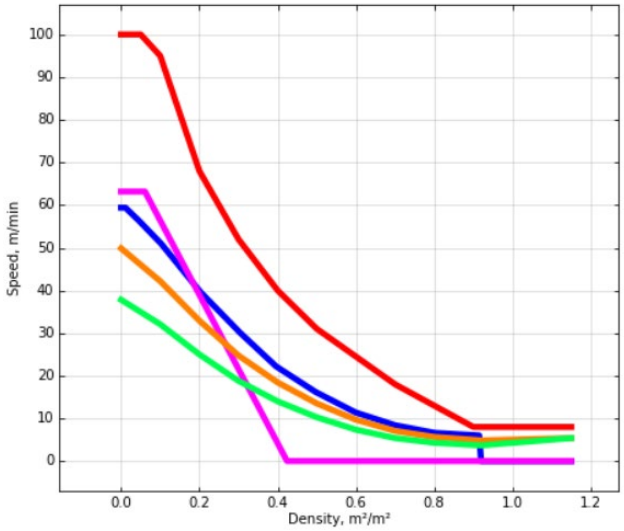
Corridor



Door, 1 m width



Stair down



Verification example 1 - Test case FDS-EVAC, Test 6.3.3

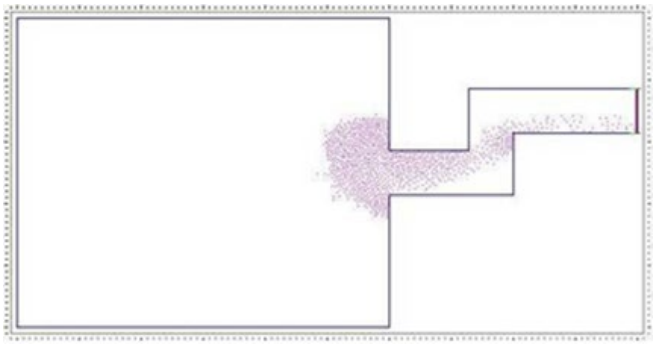
Test case model – 1000 people in a room 50x60 meters, connected to exit with corridor 7.2 meter wide with two turns. Goal – comparison with several other simulation models.

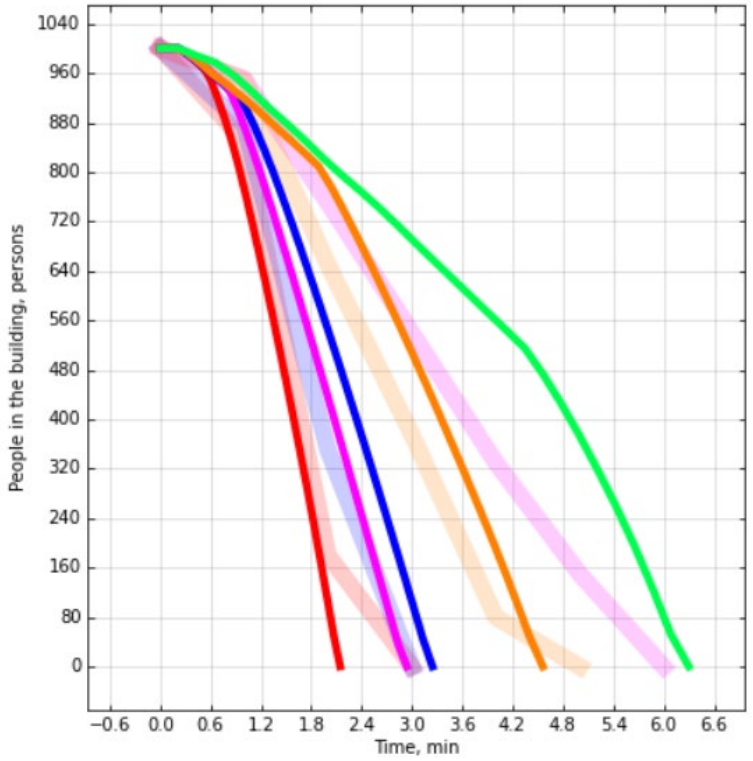
Simulation results, fundamental diagrams options:

-- Fire risk assessment guidance, Russia
- DIN 18009-2, Germany
- SFPE Guide, USA
- Predtechenskii, normal movement
- Predtechenskii, comfort movement

Reference data:

FDS-EVAC option 1
FDS-EVAC option 2
Exodus
Simulex





Verification example 2 - WTC1 evacuation at 11 september 2001

Goal – comparison with observed data – evacuation of 7560 survivors located in WTC1 from 3 to 92 floor

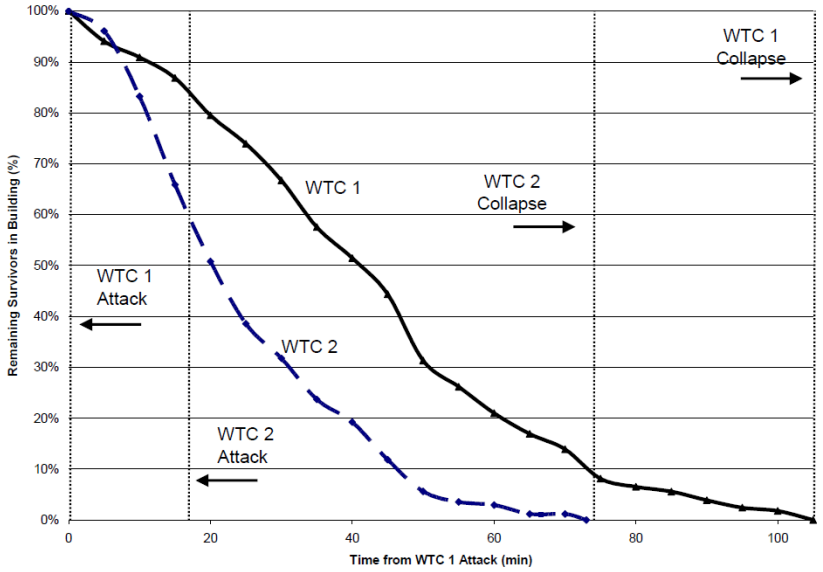
Simulation results, fundamental diagrams options:

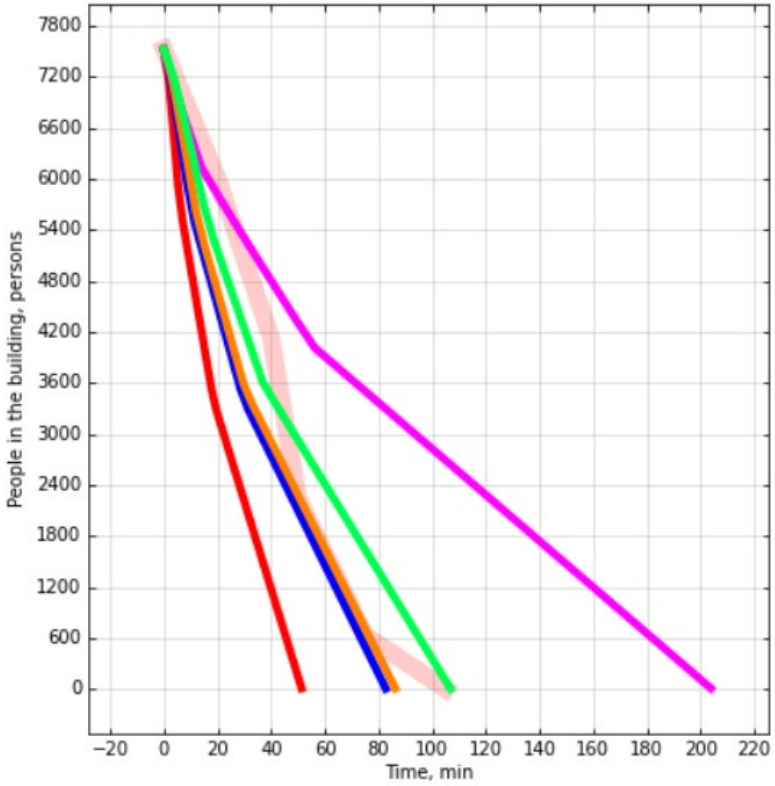
-- Fire risk assessment guidance, Russia - DIN 18009-2, Germany - SFPE Guide, USA

- Predtechenskii, normal movement - Predtechenskii, comfort movement

Reference data:

data from NCSTAR 1-7 report





Conclusions

- Software tools are developed and now are available for betta testing – Revit Add-In and linked FSE modelling processors and reporters

- Macroscopic evacuation model for pedestrian movement at fire evacuation and normal circulation, suitable for BIM-FSE integration, is developed and is available for betta testing and verification

Thank you for your attention

Site: NATOMASENG.COM

Email: vgrachev@natomaseng.com